

SOME OBSERVED INTERRELATIONSHIPS BETWEEN THE COVER OF AQUATIC VEGETATION AND VARIOUS PHYSICAL PROPERTIES OF THE WATER MEDIUM

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ABSTRACT

High pH and oxygen but low total carbon dioxide values were recorded from water at sites containing high percentage covers of predominantly submerged aquatic vegetation. The converse was true in water at sites containing very dense covers of predominantly rooted-floating and free floating aquatic vegetation. The cover of submerged aquatic vegetation was shown to be influenced by the turbidity of the water and also by shading, particularly by that of floating aquatic vegetation.

UITTREKSEL

SOMMIGE ONDERLINGE VERWANTSAPPE WAARGENEEM TUSSEN DIE WATERPLANT-BEDEKKING EN VERSKEIE FISIESE EIENSKAPPE VAN DIE WATERMEDIUM

Hoë pH en suurstof – maar lae koolsuurgas waardes kom voor in water uit standplase met 'n hoë persentasie bedekking van hoofsaaklik onderwaterse hidrofiëte. Die teenoorgestelde het egter geblyk in water uit standplase met 'n digte bedekking van hoofsaaklik geworteld-drywende en drywende plantegroei. Die bedekking van onderwaterse hidrofiëte word deur die turbiditeit drywende plantegroei.

INTRODUCTION

The following observations represent additional field data collected during the course of a detailed ecological survey conducted on the aquatic plants in the Pongolo River flood plain pans (Musil, Grunow & Bornman, 1973). These pans are situated along the Pongolo River in the North-east section of Tongaland between the Strijdom Dam at Jozini and the confluence of the Pongolo and Usutu Rivers in the Co-ordinates 27°S 32°E (quarter degree square A). For the purposes of this study the aquatic plants include all the macroscopic plants, found growing in water.

MATERIAL AND METHODS

At various points on selected pans in the Pongolo River flood plains, sample sites were located after subjectively assessing the overall species composition and habitat conditions. It was regarded as most important that each of these

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sites be as uniform as possible. Each sampling site was subdivided into stands (stand samples) which followed contours representing various depths; the contour lines were more or less parallel to the shore (Fig. 1).

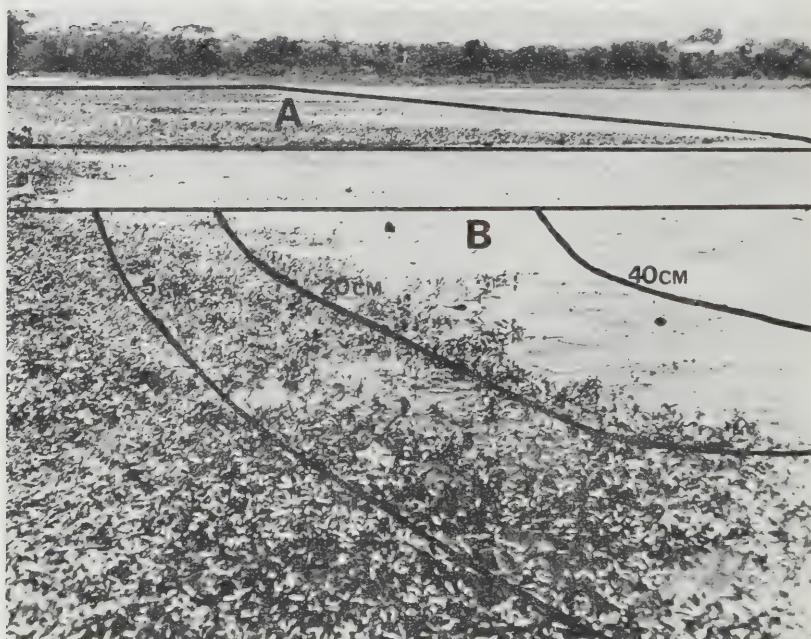


FIG. 1.

View southward of eastern shores of Omengu Pan with two sample sites A and B. Sample site B is subdivided into stands of 5, 20 and 40 cm water depths.

Frequencies, covers, and importance values of species were obtained in the following manner:

- (1) Species frequency was calculated from data obtained from forty 0.25 m^2 quadrats thrown in a stratified random fashion in each stand. Curves (Fig. 2) were constructed from data obtained from three different stands (a) containing a dense cover, (b) an intermediate cover and (c) a low cover of aquatic vegetation, to determine whether this number of quadrats was a satisfactory sample size. Thirty quadrats per stand was found to be the minimum satisfactory sample size.

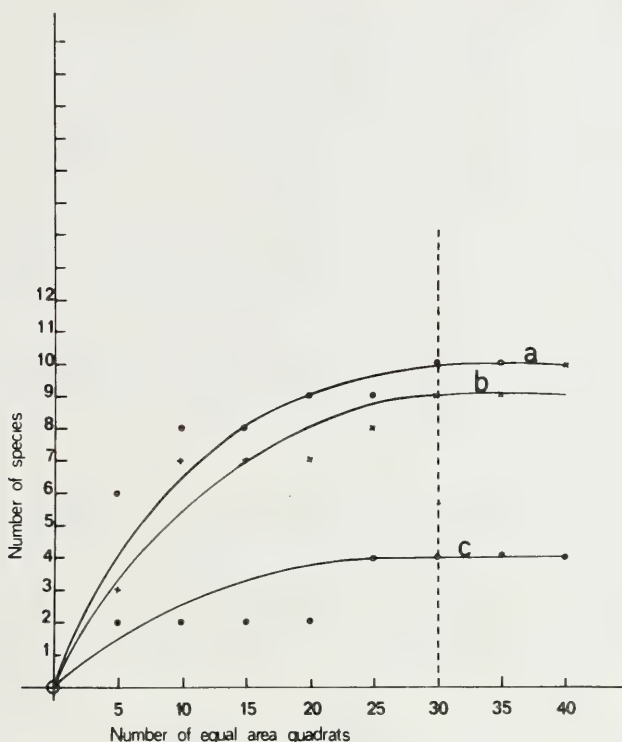


FIG. 2.
Species-area relationships from three different localities.

- (2) Species cover was calculated from point quadrats thrown in a stratified random fashion in each stand. Point quadrats were thrown until 80 strikes on the dominant plant species present were obtained. This ensured that the information content in each stand was kept constant. Standard errors of the means calculated on point quadrat data, sampled in various test stands with intermediate covers, prior to the investigation indicated that the above-mentioned number of strikes would ensure that the ensuing data had a standard error of less than 10 per cent of the mean. A Chi-square test for homogeneity, that is, uniformity of distribution of the plant species present was also conducted on point quadrat data obtained in each

stand. For the same reason and in the same way as Curtis and McIntoch (1951), only the strikes contributed by species with a relative percentage cover of 25 and above were tested for homogeneity at the 5 per cent level of significance. Point quadrat data taken sequentially were divided into four groups for the purpose of the test. The Chi-square test, therefore, had three degrees of freedom corresponding to a tabular value of 7,815. If a calculated value for the observed data was equal to or smaller than this, it was taken to indicate homogeneity.

- (3) Importance values of species in each stand were calculated according to the formula: $IV = 2 \text{ Relative \% Cover} + \text{Relative \% Frequency} / 3$. Species density was not included in the formula as individuals could not be distinguished in some species of aquatic plants, particularly those exhibiting a stoloniferous habit, e.g. *Ludwigia stolonifera* (Guill. and Perr.) Raven., *Echinochloa pyramidalis* (Lam.) Hitchcock and Chase., *Ipomoea aquatica* Forsk. The relative percentage covers were regarded more significant and were, therefore, weighted appropriately.

Water

Water samples and readings were taken at midday as far as possible on clear calm days. The pH of the water in each stand was measured with a portable

TABLE 1
Effect of vegetation type on pH of surrounding water.

Pan	Date	Vegetation	Some principal species	Depth of Water cm	Average pH
Nhlole	September	rooted/floating	<i>Nymphaea lotus</i>	40	7,5
Nhlole	September	rooted submerged	<i>Najas pectinata</i> <i>Potamogeton crispus</i>	60	8,2
Msinyeni	May	rooted submerged	<i>Potamogeton crispus</i>	40	7,5
Msinyeni	May	rooted/floating	<i>Nymphaea lotus</i>	40	7,2
Sokunte	October	rooted/floating	<i>Echinochloa pyramidalis</i> <i>Ludwigia stolonifera</i>	5	7,7
Sokunte	October	rooted submerged	<i>Najas pectinata</i>	40	8,2
Sokunte	October	rooted submerged	<i>Najas pectinata</i>	100	8,1
Mandlankunzi	June	rooted submerged	<i>Potamogeton crispus</i>	50	7,7
Mandlankunzi	June	rooted/floating	<i>Ludwigia stolonifera</i> <i>Pistia stratiotes</i> <i>Scirpus cubensis</i>	50	7,1
Mandlankunzi	September	rooted submerged	<i>Potamogeton crispus</i>	50	8,9
Mandlankunzi	September	rooted/floating	<i>Ludwigia stolonifera</i> <i>Pistia stratiotes</i> <i>Scirpus cubensis</i>	50	7,1

meter while O_2 concentrations were measured using a galvanic-cell oxygen analyser with a lead-silver electrolyte probe. The total CO_2 ($HCO_3 + CO_3$) was calculated from the total alkalinity which was estimated according to the method of Golterman (1969). Generally ten readings of pH and O_2 concentrations were taken at each sampling while four water samples were taken for determination of total alkalinity. The above number of readings were sufficient to give a standard error of less than one per cent of the mean for pH and O_2 concentrations and five per cent of the mean for total CO_2 ($HCO_3 + CO_3$).

A secchi disc was used to determine the turbidity of the water in each of the stands. In most cases secchi disc readings were determined over a number of days to obtain the best average figure for a particular stand.

RESULTS

An initial comparison between the average pH values recorded in some stands and the type of aquatic vegetation present, whether rooted and free floating

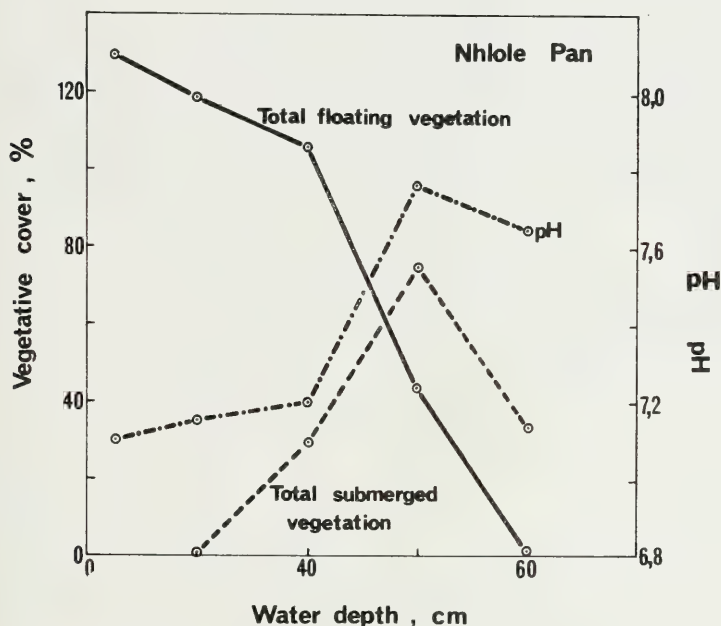


FIG. 3.
Effect of vegetation type and its cover on pH of surrounding water.

or submerged, are represented in Table 1. Neutral or more acidic values were found in stands containing predominantly free floating and rooted-floating vegetation and alkaline values in stands with predominantly submerged aquatic vegetation.

The possibility that each vegetation type modified the pH of the surrounding water was illustrated in Nhlole Pan. When the total percentage covers of (a) the rooted and free floating aquatic vegetation and (b) the submerged aquatic vegetation, as measured in a series of stands of increasing depth, were plotted against the average pH values recorded in each of these stands at two separate dates (Fig. 3), it was found that as the pH values rose, the total percentage cover of the free floating and rooted-floating aquatic plants decreased while those of the submerged aquatics increased with increasing depth. As the percentage cover of the submerged aquatics declined from the 60 to the 80 cm depth, so did the pH values. This indicated that it was possibly the actual quantity of each vegetation type present that determined the pH of the water immediately sur-

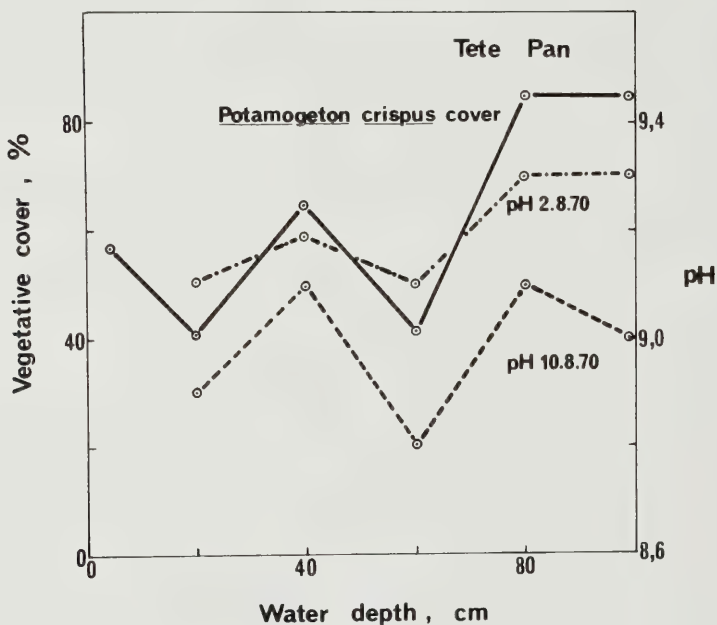


FIG. 4.
pH of water as influenced by the cover of submerged aquatic vegetation.

rounding it. The greater the percentage cover of submerged aquatic vegetation recorded the more alkaline the pH was.

This phenomenon was clearly illustrated in a comparison between the percentage cover of *Potamogeton crispus* and the average pH values, measured on two different dates in a series of stands of increasing depth at one sample site on Tete Pan. Figure 4 shows that all the pH values were high, as expected, since the only species present was *Potamogeton crispus*, a submerged rooted aquatic. The more alkaline the pH value the higher the actual percentage cover recorded for *Potamogeton crispus* in each stand. In fact, curves for pH and percentage cover of this species complemented one another.

Like pH, the differences measured in the total CO₂ and O₂ content of pan water at various localities were also attributed to the quantity of each vegetation type found in the immediate vicinity. Table 2 shows that higher pH and O₂ values and lower total CO₂ values were recorded from water in stands containing high percentage covers of predominantly submerged aquatic vegetation (Tete). On the other hand, low pH and O₂ values but high total CO₂ values were recorded in stands containing extremely high percentage covers of predominantly rooted-floating and free floating vegetation (Mniati, Mandlankunzi).

The low total O₂ values but high pH values were attributed to the removal, by submerged aquatic vegetation, of CO₂ from the water during photosynthesis, resulting in a decrease in the total carbonic acid content present in solution, this initiating a rise in pH. The high O₂ values recorded from these stands were considered due to the O₂ released into the water by the submerged aquatic vegetation during photosynthesis. The high total CO₂ and low O₂ content of

TABLE 2
A comparison between pH, total CO₂ (as HCO₃+CO₃) and O₂ values recorded in stands with different total percentage covers.

Pan	Site	Depth of water cm	Total % cover floating vegetation	Total % cover submerged vegetation	Average pH	Average CO ₂ (as HCO ₃ +CO ₃) mg/l	Average O ₂ mg/l
Tete	E	80	—	85,0	9,2	29,9	9,7
Tete	E	100	—	85,0	9,1	23,3	9,6
Nhlole	DCA	20	119,6	—	7,1	69,8	6,0
Omengu	NEA	80	110,6	8,0	7,4	62,4	5,1
Mniati	M	80	180,0	—	6,4	213,9	2,0
Mandlankunzi	MI	80	258,2	13,1	6,3	117,9	1,9
Mandlankunzi	MI	60	248,9	5,7	6,3	117,9	1,9
Subjective visual assessment of cover.							
Banzi	SW	—	100,0	0,0	6,3	—	3,4
Banzi	NE	—	40,0	5,0	7,1	—	8,0

water in stands was attributed to the active respiration of the fauna beneath the vegetation and to the submerged portions of the plants. The acidic pH values, on the other hand, were attributed to an increase in carbonic acid and possibly also to humic acids arising from decomposing plant litter of the floating vegetation. It was considered, too, that diffusion of O_2 from the atmosphere into the water and CO_2 from the water into the atmosphere was limited by the dense cover of floating vegetation.

In stands with somewhat intermediate covers of submerged and free floating and rooted-floating aquatic plants more or less intermediate pH, total CO_2 , and O_2 values were recorded (Nhlole, Omengu). It is possible that the ultimate values recorded in these stands depended on the combined reaction of each vegetation type with the surrounding water, the extent of which depended on the quantity of each vegetation type present.

The reaction of the submerged aquatic vegetation on the surrounding water was further emphasised in general seasonal studies conducted in Tete Pan. In

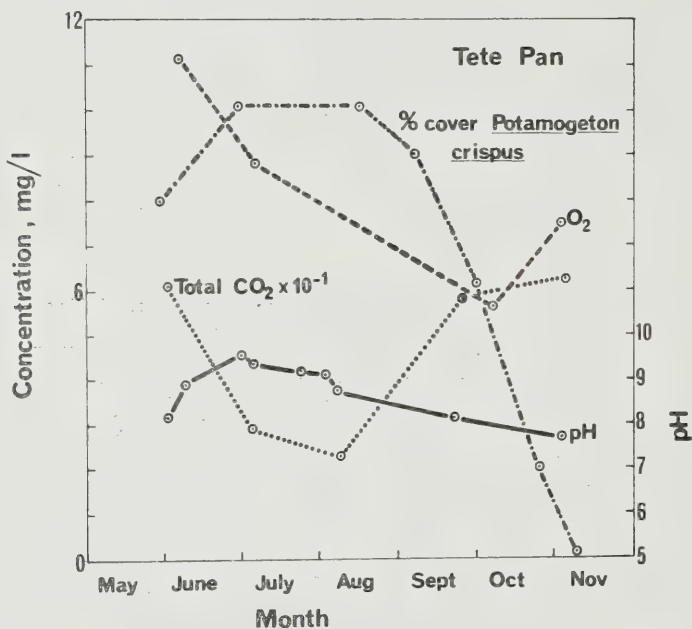


FIG. 5.
Seasonal changes in pH and total CO_2 concentration of water as influenced by changes in cover of *Potamogeton crispus*.

this pan a correlation was shown to exist between the pH and total CO_2 as measured monthly in representative water samples and the percentage of total water surface area covered by *Potamogeton crispus* as subjectively assessed monthly from June to November (Fig. 5). The curves show that a peak cover of *Potamogeton crispus* during the July/August period coincided with peak pH values and minimum total CO_2 values recorded in this pan during this period. As the cover of *Potamogeton crispus* decreased towards November the total CO_2 values rose with a concomitant drop in pH.

The effects of shading of rooted and free floating aquatic plants on the cover of submerged aquatic plants is illustrated in a graph plot of the sum total of importance values of submerged aquatic vegetation and those of rooted and free floating aquatic vegetation as measured in a series of stands of increasing depth at one sample site on Omengu Pan (Fig. 6). The graphs are virtually

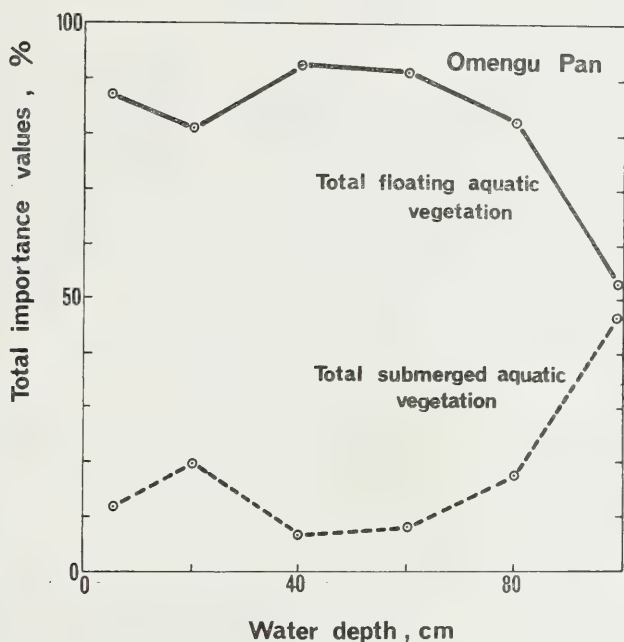


FIG 6.
The inverse relationship between floating and submerged aquatic vegetation in terms of total importance values.

inverted images of each other indicating an inverse correlation between the two types of aquatic vegetation. It is evident that the higher the importance values calculated for the rooted-floating and free floating vegetation, the larger the total relative percentage cover and frequency and consequently the more intense the shading effects on the submerged aquatic vegetation. This would possibly reduce photosynthesis in the submerged aquatic vegetation and consequently limit its growth.

The availability of light to the submerged aquatic plants was not only limited to the effect of shading by rooted-floating and free floating aquatic plants but also to the turbidity of the water. For example, at one particular sampling site on the leeward margin of Tete Pan, the percentage covers of *Potamogeton crispus*, the dominant submerged aquatic plant species present, were assessed in a series of stands of increasing depth. A series of secchi disc readings were also taken in these stands over a number of days. Figure 7 illustrates the results

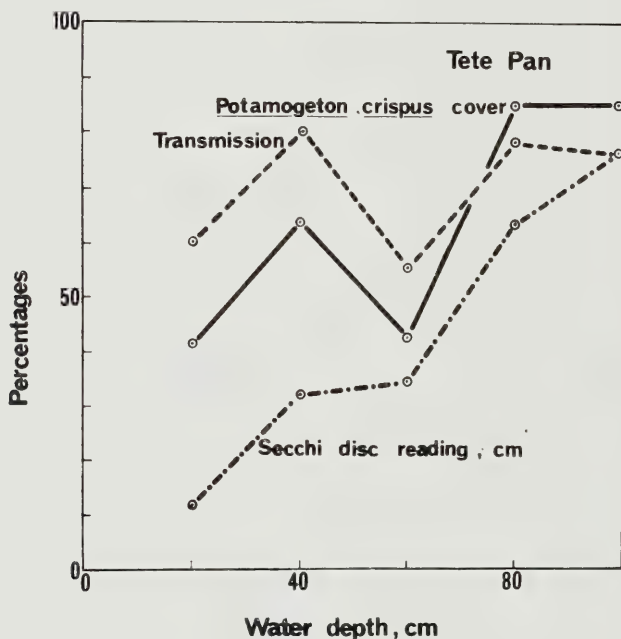


FIG. 7.
Relationship between percentage cover of *Potamogeton crispus* and turbidity of water plotted as percentage transmitted light.

graphically. The curves show that as the water depth increased so did the secchi disc readings, the water obviously becoming progressively less turbid. The smaller average secchi disc readings measured at 20, 40 and 60 cm depths were attributed to the disturbance of the bottom substrate by cattle being brought to water every day. In fact, as Table 3 shows secchi disc readings in these three stands in the early morning before the cattle came to water were much higher than those later in the day.

TABLE 3
Secchi disc readings at different depths in Tete Pan.

Water depth cm	Average secchi disc reading cm	
	August early morning	August late afternoon
20	19,0	5,0
40	33,0	31,5
60	35,5	32,5
80	66,0	61,0
100	76,5	—

Comparison between the average secchi disc readings and the percentage covers of *P. crispus* recorded in each stand (Figure 7) revealed that as the percentage cover of *P. crispus* increased from 20 to 40 cm depth so did the average secchi disc readings. At 60 cm depth, however, the average secchi disc readings remained more or less constant while the percentage cover of *P. crispus* decreased. As the secchi disc readings again increased at 80 and 100 cm, so did the percentage covers of *P. crispus*. From these observations it appeared that if the water depth remained constant and its turbidity increased, the percentage cover of *Potamogeton crispus* would decrease, while at a constant turbidity (or secchi disc reading) if the water depth increased the percentage cover of *Potamogeton crispus* would correspondingly decrease.

The relationship between the percentage cover of *P. crispus* and the turbidity of the water became very much clearer when the average secchi disc readings were standardised and plotted as percentage light transmitted at each depth. This was calculated according to the formula, $\text{Average secchi disc reading cm} \times 100 / \text{depth of water cm}$. Therefore, an average secchi disc reading of 12 cm at 20 cm water depth gave a value equivalent to 60 per cent transmission. When a plot of the per cent transmission was compared with that of the per cent cover of *P. crispus*, the curves appeared to be mutually complementary, that is, the greater the per cent transmission of light the larger the per cent cover of *Potamogeton crispus*.

In concluding it should also be pointed out that the depth at which *Potamogeton crispus* yielded an optimal percentage cover was generally equivalent

to the maximum secchi disc reading measured in a particular pan: For example, the maximum secchi disc reading measured in Tete Pan at the beginning of August was 78 cm while the optimum percentage cover of *P. crispus* corresponded to the 80 cm depth. In Msinyeni the maximum secchi disc reading measured in October was 10 cm while the optimum percentage cover of *P. crispus* was measured at 10 cm depth (Table 4).

TABLE 4
Relationship between the turbidity of water and percentage cover of *Potamogeton crispus*.

Water depth cm	Percentage cover from point quadrat data	
	Tete Pan (August)	Msinyeni Pan (October)
5	57	12
10	—	25
20	42	13
40	65	2
60	43	—
80	85	—
100	85	—
*Maximum secchi disc reading Tete Pan (August)=78 cm		
*Maximum secchi disc reading Msinyeni Pan (October)=10 cm		

CONCLUSIONS

The high pH and O₂ values and low total CO₂ values recorded from water containing high covers of predominantly submerged aquatic vegetation were attributed to a removal of CO₂ and release of O₂ into the water by the photosynthesising vegetation. Alternatively, the low pH and O₂ values but high total CO₂ values recorded from water containing extremely dense covers of predominantly rooted-floating and free floating aquatic vegetation were perhaps attributable to the active respiration of the fauna beneath the vegetation and to the submerged portions of the plants, as well as to humic and other organic acids arising from decomposing plant litter from the floating vegetation.

The cover of submerged aquatic vegetation was shown to be limited by the degree of light penetration into water which, in turn, was dependent on the degree of shading by the floating aquatic vegetation and the turbidity of the water. It was considered that the less light available to the submerged aquatic plants, the smaller their growth rate due presumably to a lower photosynthetic activity.

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